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A quadrifilar helix antenna

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(56) Documents cited
GB0840850 A
"Resonant Quadrifilar Helix" C.C. Kilgus, IEEE Trans. Vol. AP-17, May 1969

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INT CL^5 **H01Q**
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22437

1/5

Fig. 1

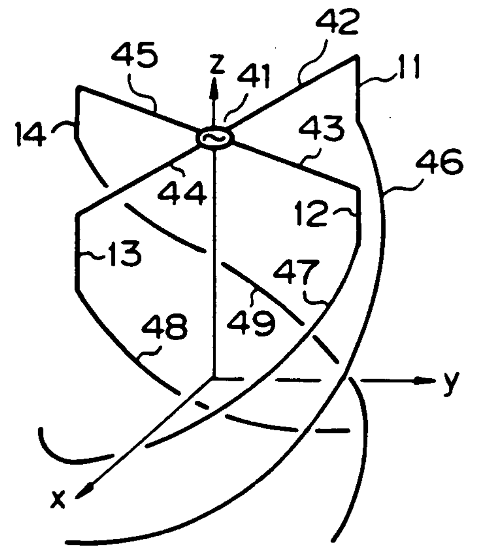


Fig. 2

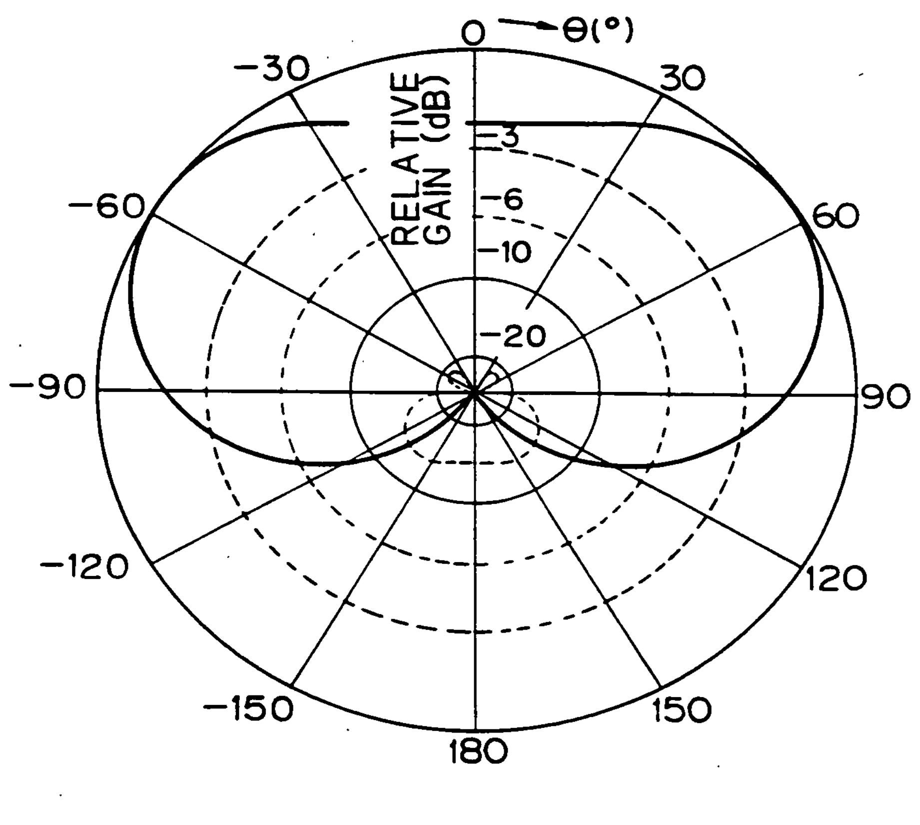
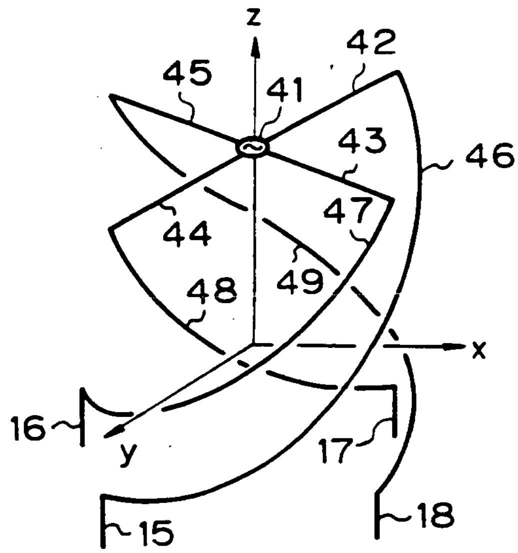


Fig. 3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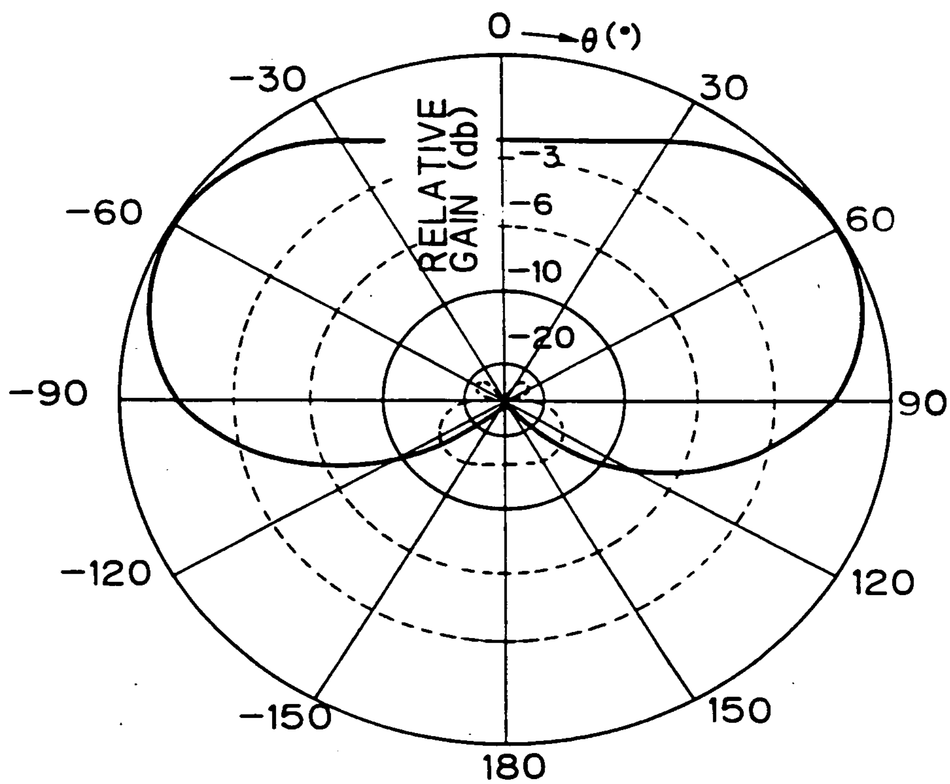
45
41
43
46
47
44
49
48
x
16
y
17
18
15

Fig. 4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θ(°)
-30
30
RELATIVE GAIN (db)
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-6
-10
-20
-60
60
-90
90
-120
120
-150
150
180

Fig. 5

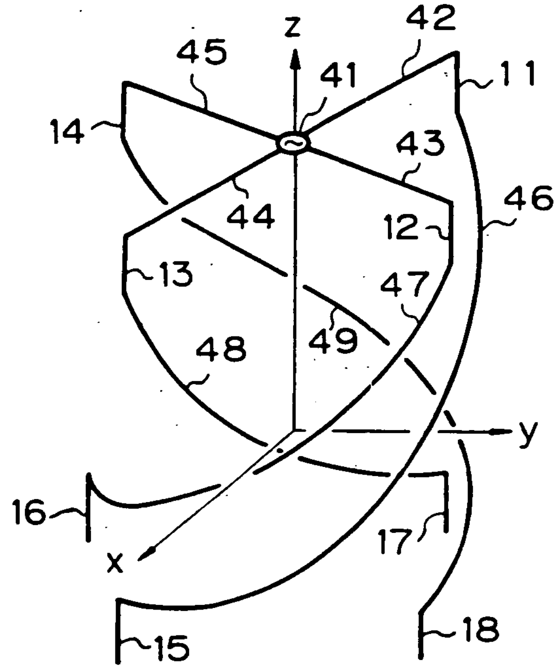


Fig. 6

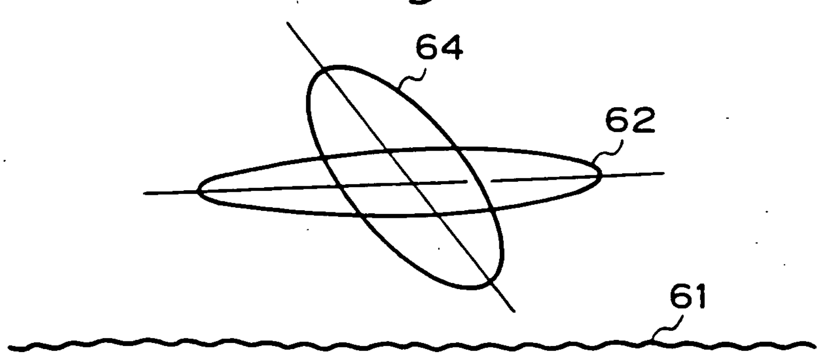


Fig. 7

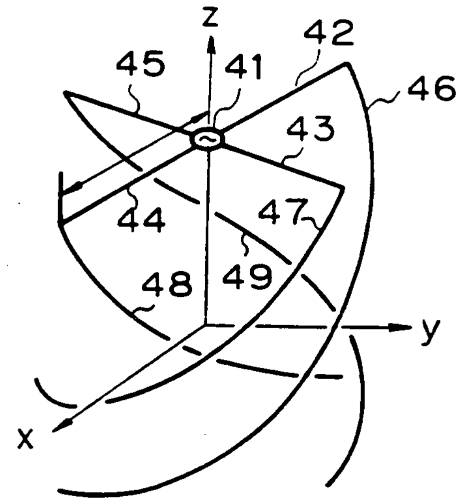
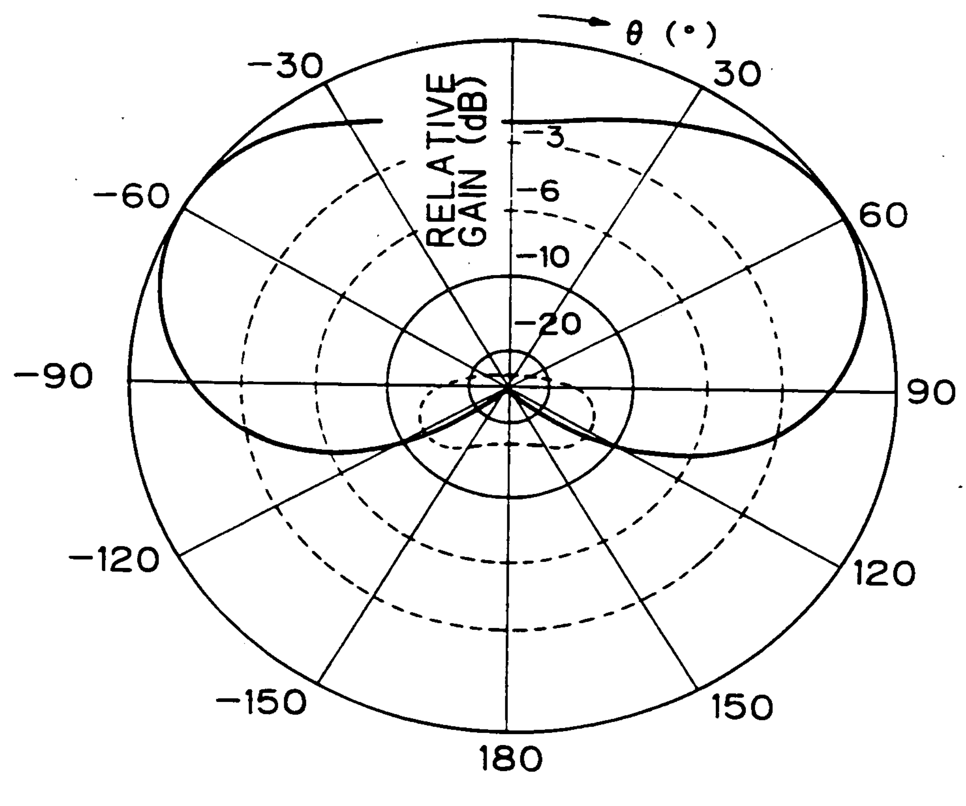

z
42
45
41
46
43
44
47
48
49
y
x

Fig. 8


θ (°)
-30
30
RELATIVE GAIN (dB)
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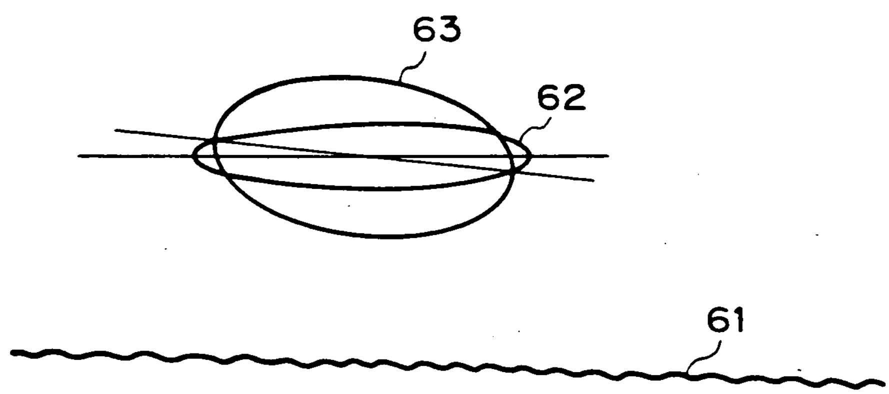
-6
-10
-20
-60
60
-90
90
-120
120
-150
150
180

Fig. 9



2243724

A quadrifilar Helix Antenna

The present invention relates to a small mobile antenna in a mobile satellite communication system. The mobile satellite communication system can provide a high quality communication service in a wide area. A communication service for ships is now available all over the world by using the INMALSAT system. A mobile communication for an aircraft, and/or a land mobile station is also now developed. In a mobile satellite communication system, a small antenna which has half sphere coverage does not need to track a desired satellite, and is considered promising for making an antenna small. Further, a circularly polarized radio wave is used for a mobile satellite communication system, and a mobile antenna with a wide angle, and excellent axis-ratio characteristics has been required. With this in mind, a quadrifilar helix antenna which has four coils is considered to be one of the candidates for a small mobile antenna. A prior quadrifilar helix antenna, for example, is shown in "Resonant Quadrafilar Helix" by C.C.Kilgus in IEEE Trans. vol.AP-17, May 1969.

Fig.7 shows a structure of a prior quadrifilar helix

antenna. In the figure, the numeral 41 is a feed circuit, 42 through 45 are feed lines, 46 through 49 are helix conductors. The helix conductors 47, 48 and 49 are fed with the phase differences 90°, 180° and 270°, respectively, in comparison with that of the helix conductor 46, and the antenna radiates circularly polarized waves. The shape of the antenna is defined by its pitch distance, the number of the each helix turns and radius of helix conductors. One example of those parameters for achieving almost half sphere beam are 1λ of pitch distance, 0.5 turn, and 0.1λ of radius of helix conductors, where λ is wavelength to be used.

Fig.8 shows the radiation characteristics of the prior quadrifilar helix antenna having said parameters. In Fig.8, θ is the angle between a observation point and a helix axis, a solid line and a dotted line show the radiation pattern for a co-circular polarization, and that for the anti-circular polarization, respectively.

A prior quadrifilar helix antenna has a wide beam, and excellent axis-ratio characteristics in wide area as shown in Fig.8.

However, a prior quadrifilar helix antenna has the disadvatages that the value of the parameters for the desired characteristics are severely restricted, and it is impossible to provide a smaller sized antenna.

Further, in a mobile satellite communication system which includes a ship and/or an aircraft, a mobile antenna receives not only a direct wave from a satellite, but also reflected waves by the sea-surface. The direct wave and reflected waves interfere with each other, and the receive level is subject to fading which is called a multipath fading due to sea-surface reflection (denoted by "multipath fading" hereafter).

In a mobile satellite communication system, a power margin is provided so that the communication is possible with the defined percent of the time even under the decreased level by the multipath fading. When the power margin is large, a satellite must transmit with high power. The wider an antenna beam is and the lower an elevation angle of a satellite is, the larger the effect of multipath fading due to sea-surface reflection is. Therefore, it is desirous that the mobile antenna is not affected by multipath fading.

By the way, when a circularly polarized wave is reflected by the sea-surface, the reflected wave has an elliptical polarization whose major axis is almost parallel to the sea-surface. Therefore, from the view point of rejection of reflected waves, it is preferable that the polarization characteristics of the mobile antenna in the direction of the reflected waves is

orthogonal to those characteristics of the reflected waves. In other words, it is preferable that the major axis of an elliptical polarization is directed as vertical as possible.

However, a prior quadrifilar helix antenna has the elliptical polarization of which major axis is directed in an almost horizontal direction, and therefore, it tends to be affected by the multipath fading. This is explained in accordance with Fig.9, which shows the polarization characteristics of the sea-surface reflection waves with the elevation angle of 5 degrees, and those of the antenna's sea-surface reflection direction (5 degrees under horizon) of a prior quadrifilar helix antenna. In the figure, the numeral 61 is the sea-surface, 62 is polarization characteristics of the sea-surface reflection waves, and 63 is polarization characteristics of a prior quadrifilar helix antenna.

It should be noted in Fig.9 that a prior quadrifilar helix antenna has the elliptical polarization whose major axis is essentially parallel to the sea-surface. Therefore, a prior antenna receives a significant amount of the sea-surface reflection waves, and is subsequently affected by the multipath fading.

It is an object of the present invention to overcome

the disadvantages and limitations of a prior quadrifilar helix antenna by providing a new and improved quadrifilar helix antenna.

It is also an object of the present invention to provide a quadrifilar helix antenna which reduces the effect of the multipath fading, and is smaller in size than a prior quadrifilar helix antenna.

The above and other objects are attained by a quadrifilar helix antenna comprising; a feed circuit located on a z-axis of xyz rectangular coordinates system; four feed lines extending from said feed circuit so that those feed lines are perpendicular to one another and are parallel to xy plane; four helix conductors of which center axis coincides with z-axis, and all the helix conductors have the same winding direction; and a first linear portion parallel to the z-axis, all the first linear portions parallel to the z-axis having the same length.

The foregoing and other objects, features, and attendant advantages of the present invention will be appreciated as the same become better understood by means of the following description and accompanying drawings

wherein;

Fig.1 shows a structure of a quadrifilar helix antenna according to the present invention,

Fig.2 shows the radiation pattern of a quadrifilar helix antenna of Fig.1,

Fig.3 shows a structure of the second embodiment of the quadrifilar helix antenna according to the present invention,

Fig.4 shows the radiation pattern of the quadrifilar helix antenna of Fig.3,

Fig.5 shows a structure of the third embodiment of a quadrifilar helix antenna according to the present invention,

Fig.6 shows polarization characteristics of the sea-surface reflection waves, and the quadrifilar helix antenna of Fig.5 in the sea-surface reflection direction,

Fig.7 shows a prior quadrifilar helix antenna,

Fig.8 shows the radiation pattern of the prior antenna of Fig.7, and

Fig.9 shows polarization characteristics of the sea-surface reflected waves, and the antenna in the sea-surface reflection direction in the prior art.

(Embodiment 1)

Fig.1 shows the quadrifilar helix antenna according

to the present invention. In the figure, the quadrifilar helix antenna has the feed circuit 41 which is located on the z-axis of the xyz rectangular coordinates system, four feed lines 42 through 45 extending from said feed circuit 41 so that those feed lines are perpendicular to one another and are parallel to the xy plane, four helix conductors 46 through 49 attached to one end of each of said feed lines so that the center axis of the helix coincides with the z-axis, and all the helixes are wound in the same direction, and four linear conductors 11 through 14 inserted between each of said feed lines 42-45 and each of said helix conductors 46-49 so that those linear conductors are parallel to the z-axis and all the linear conductors have the same length.

The opposite end of each helix conductors, which has no linear conductor attached, 46-49, may be open as shown in Fig.1. Alternatively, each of said ends may be connected with one another by using linear conductors which are perpendicular to one another.

Fig.2 shows the radiation pattern of the antenna of Fig.1 for the parameters in Fig.2 that the length of the linear conductors 11-14 is 0.04 λ , the pitch length of the helix conductors 46-49 is 1 λ , the number of turns of each helix conductors 46-49 is 0.5, the radius of the helix is 0.04 λ , where λ is the wavelength. It can be

seen from Fig.2 that the quadrifilar helix antenna with above parameters has the wide beam, and excellent axis-ratio characteristics as in the case of those of Fig.8.

It should be also noted that the radius of the helix in Fig.1 is only less than almost half of that of Fig.8.

The preferable parameter range of the antenna for providing the excellent characteristics in terms of radiation pattern and axial ratio is 0.02-0.06λ for the length of the linear conductors 11-14, 0.9-1.1λ for the pitch length of the helix conductors 46-49, and 0.4-0.6 for the number of turns of the helix and 0.02-0.06λ for the radius of the helix.

(Embodiment 2)

Fig.3 shows the structure of the second embodiment of the present invented quadrifilar helix antenna. In the figure, the quadrifilar helix antenna has the feed circuit 41 located on the z-axis of the xyz rectangular coordinates system, four feed lines 42 through 45 extending from said feed circuit 41 so that those feed lines are perpendicular to one another and are parallel to xy plane, four helix conductors 46 through 49 attached to one end of each of the related feed lines so that the center axis of the helix coincides with z-axis, and the winding direction of all the helixes is same, and four

linear conductors 15 through 18 attached to one end of each helix conductors so that those linear conductors are parallel to the z-axis, and all the helix conductors have the same length.

An opposite end of the linear conductors 15-18 at which no helix conductors are attached may be open as shown in Fig.3. Alternatively, said ends may be short-circuited by using linear conductors perpendicular to one another.

One example of the parameters which provides an excellent radiation pattern and axis-ratio characteristics is that 0.04 λ for the length of the linear conductors 11-14, 1 λ for the pitch length of the helix conductors 46-49, 0.5 for the number of turns of the helix and 0.04λ for the radius of the helix.

Fig.4 shows the radiation pattern of the antenna which has said parameters. It should be noted in Fig.4 that the present antenna has the wide beam and good axis-ratio characteristics as is the case of Fig.8. Since the radius of the present antenna is less than almost half as compared with that of the prior art of Fig.8, the present invention may provide the smaller antenna.

The preferable range of the antenna parameters to provide the excellent characteristics in terms of radiation pattern and axial ratio is that 0.02-0.06λ

for the length of the linear conductors 11-14, 0.9-1.1λ for the pitch length of the helix conductors 46-49, 0.4-0.6 for the number of turns of the helix and 0.02-0.06λ for the radius of the helix.

(Embodiment 3)

Fig.5 shows the third embodiment of the present helix antenna. In the figure, the antenna has the feed circuit 41 located on the z-axis of the xyz rectangular coordinates system, four feed lines 42-45 extending from said feed circuit 41 so that those feed lines are perpendicular to one another and are parallel to the xy plane, four helix conductors 46-49 so that the center axis coincides with the z-axis, and all the helix conductors have the same winding direction, first four linear conductors 11 through 14 inserted between the feed lines 42-45, and the helix conductors 46-49 each other so that those linear conductor are parallel to the z-axis and all the linear conductor have the same length, and the second four linear conductors 15 through 18 attached to the other end of the helix conductors so that those linear conductors are parallel to the z-axis, and all have the same length.

An opposite end of the linear conductors 15-18 at which no helix conductors are attached, may be open as shown in Fig.5. Alternatively, said ends may be

short-circuited by using linear conductors perpendicular to each other.

The structure of Fig.5 can also provide the wide beam and the samll size of the antenna which has less radius of the helix than that of the prior art shown in Fig.7.

The range of the parameters in the case of Fig.5 to provide excellent characteristics in terms of radiation pattern and axial ratio is 0.02-0.06 λ for the length of the first linear conductors 11-14, 0.02-0.06 λ of the length of the second linear conductors 15-18, 0.9-1.1λ for the pitch length of the helix conductors 46-49, 0.4-0.6 for the number of turns of the helix , and 0.02-0.06 λ for the radius of the helix, where λ is the wavelength. It should be appreciated that the embodiment of Fig.5 has the more freedom in determining the parameters to provide excellent characteristics as compared with those of Fig.1 and Fig.3.

Fig.6 shows the polarization characteristics of the sea-surface reflection wave and the present helix antenna which has the parameters of 0.04 λ for the length of the first linear conductors 11-14, 0.04 λ for the second length of the linear conductors 15-18, 1 λ for the pitch length of the helix conductors 46-49, 0.5 for the number of turns of the helix, and 0.06 λ for the radius of the

helix. The numeral 64 shows the polarization characteristics in the sea-surface reflection direction (5 degrees below the horizon) of the present helix antenna. The major axis of the elliptical polarization of the present helix antenna in the sea-surface reflection direction (5-10 degrees below the horizon) is inclined by about 40 degree from the vertical polarization direction (50 degree from the sea-surface.)

It should be appreciated in Fig.6 that the direction of the major axis of the elliptical polarization of the present antenna has a large angle from that of the sea-surface reflection waves. Therefore, the multipath fading is expected to be reduced considerably. In our theoretical calculation for elevation angle of 5 degrees to the satellite, fading depth of about 10 dB in the case of a prior antenna is observed, while that of about 7.5 dB in the case of the present antennas. Therefore, the amount of the fading depth is improved by 2.5 dB (about half for the required power) when the present invention is employed.

As mentioned above in detail, an antenna according to the present invention may have a wider range of parameters as compared with a prior antenna, to provide the excellent antenna characteristics, and large design freedom is obtained. The size of the present

antenna is smaller than that of a prior antenna. Furthermore, the multipath fading which becomes a serious problem at low elevation angle in the mobile satellite communication can be significantly reduced.

It should be appreciated in the above embodiments, that a feed line, a linear conductor and a helix conductor may be either integral and are made of single conductive wire, or those members are made of separate conductive wires which are coupled with one another.

CLAIMS

1. A quadrifilar helix antenna comprising a feed circuit located on a z-axis of an xyz rectangular coordinate system; four feed lines extending from the feed circuit perpendicular to one another and parallel with the xy plane; and four conductors coupled with respective feed lines, each conductor having a helical portion with the centre axis of each helical portion coinciding with the z-axis, all the helical portions having the same winding direction, and a first linear portion parallel to the z-axis, all the first linear portions parallel to the z-axis having the same length.

2. An antenna according to claim 1, wherein each helical portion is attached to the respective feed line via the corresponding linear portion.

3. An antenna according to claim 1, wherein each helical portion is connected at one end to a feed line and at the other end to a respective linear portion.

4. An antenna according to claim 2, wherein each conductor further comprises a second linear portion attached to the other end of the helical portion, the second linear portions being parallel to the z-axis and all the second linear portions having the same length.

5. A quadrifilar helix antenna according to any of the preceding claims, wherein the length of each linear portion is 0.02-0.96λ, the pitch length of each helical portion is 0.9-1.1λ, the number of turns of each helical portion is 0.4-0.6, and the radius of each helical portion is 0.02-0.06λ, where λ is wavelength.

6. A quadrifilar helix antenna according to any of the preceding claims, wherein the end of each conductor remote from the feed lines is open.

7. A quadrifilar helix antenna according to any of claims 1 to 5, wherein the ends of each conductor remote from the feed lines are short-circuited to one another by auxiliary linear conductors.

8. A quadrifilar helix antenna according to any of the preceding claims, wherein each of the four conductors is integrally formed of a single wire.

9. A quadrifilar helix antenna according substantially as hereinbefore described with reference to any of the examples shown in Figures 1 to 6 of the accompanying drawings.